# Solar-Powered Treatment and Desalination System For Produced Water

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## Introduction

- **Problem Statement:**
  - Produced water that accompanies extracted oil are not often utilized.
  - Traditional purification methods have environmental challenges, resource wastage, drain natural resources and are often unsuitable for remote areas.
- **Objective Statement:**
  - This project aims to develop a green energy-powered treatment system for produced water.
- **Constraints:**
  - *Technical Constraints:* Limited green energy sources and the effectiveness of the water treatment technologies.
  - *Environmental Constraints:* Land use considerations, when large-scale solar panels are involved.
  - *Economic Constraints*: Potential high initial costs for setting up green energy infrastructure and treatment plants.
  - *Geographical Constraints:* Accessibility to remote oil extraction sites.

## Target Specifications

PH level between 6.5 – 8.5.

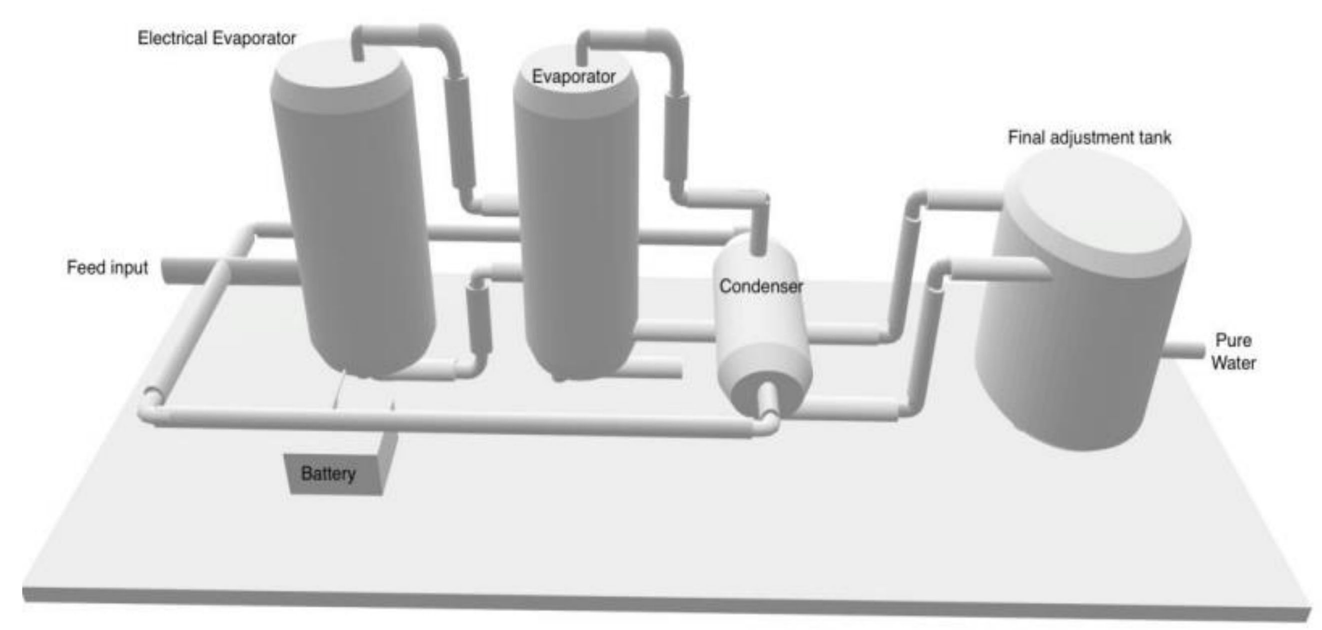
The concentration of TDS is approximately 300 ppm.

Minimum surface area for solar panels = 3500 m2 .

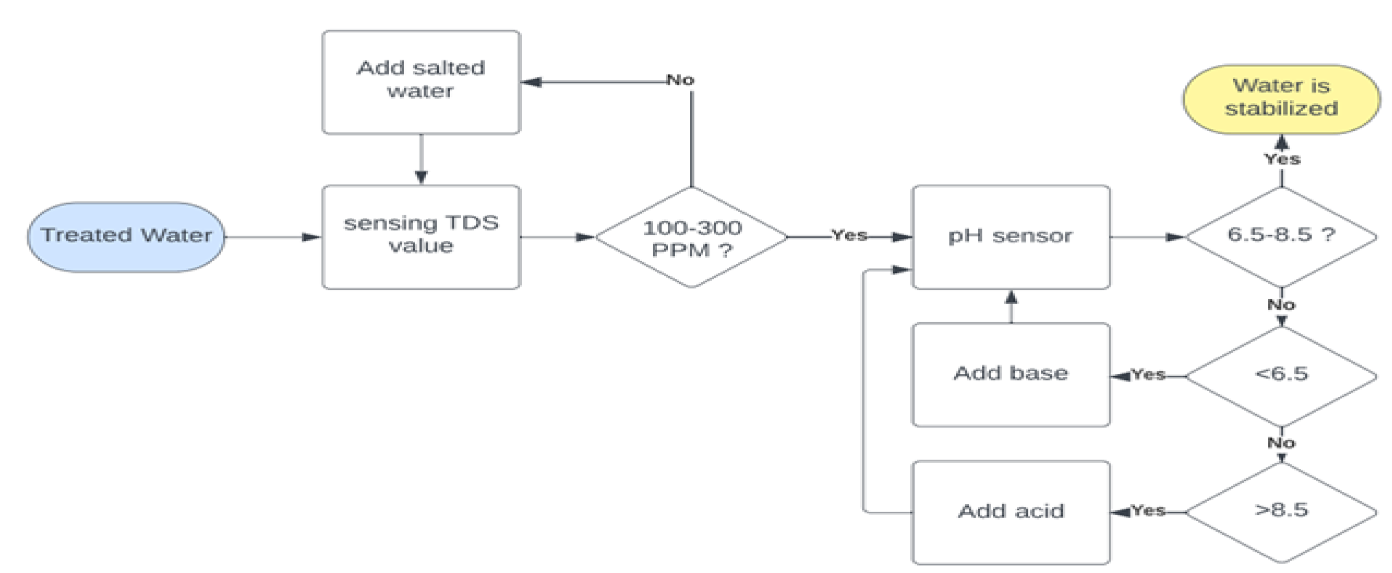
Estimated water production rate is at least 6000 L/day.

Energy generated from power supply not less than 1882 KWh/ Day.

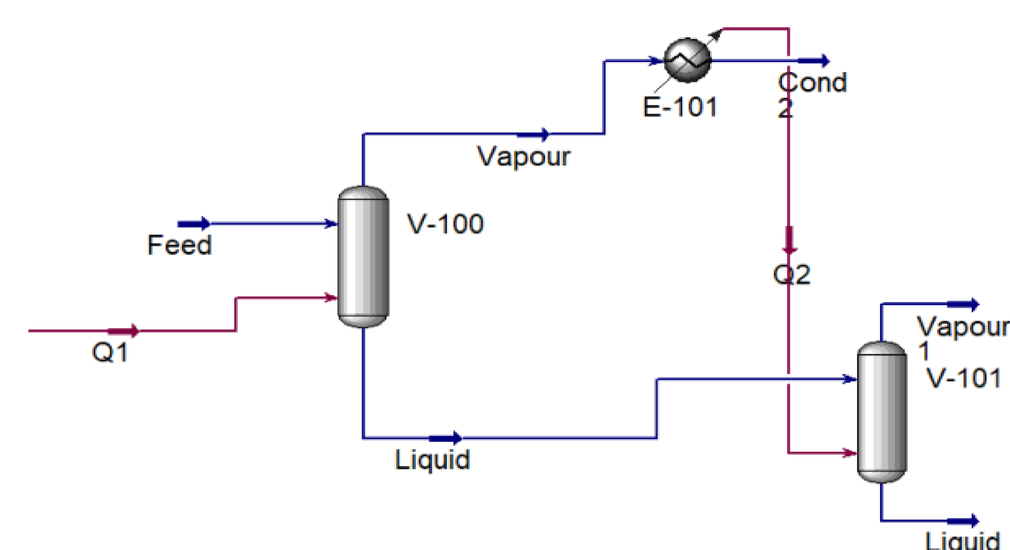
## Prototype Design




System Design




Water Treatment Control System Chart




System Simulation (Aspen HYSYS)

## Goal Programming

**Parameters:**

- C = Capacity of the tank = 10,000L
- M = water level at the tank = 0L (initially)
- G = Energy capacity = 1883 KWh/day
- e = Energy needed to fully purify 1 L of water =0.314KWh
- D = Daily demand of water in Liter = 240L/day
- n = Number of people at the GOSP = 25 person
- $c_1$ = Cost of outsourced water for 1L = 0.1 SAR
- $c_2$ = Cost of outsourced Energy for 1KWh = 0.18 SAR

**Decision Variables**:

- x = Amount of treated water per day in liters
- P = Amount of pre-treated (produced) water needed in liters per day

$$\boldsymbol{Min}\ c_1 d_1^- + c_2 d_2^-$$

**Subject to**

$$x + d_1^- - d_1^+ = n*D - M$$

$$x = \frac{26}{100} P$$

$$e*x + d_2^- - d_2^+ = G$$

$$x \le C - M$$

$$x, P, d_i^+, d_i^- \ge 0\ \forall i = 1,2,$$

## Testing and Validation

| Stream Name | Q1 |
|---|---|
| Heat Flow [kW] | 78.66 |

| Name | Vapour |
|---|---|
| Vapour | 1.0000 |
| Temperature [C] | 100.9 |
| Pressure [bar] | 1.013 |
| Molar Flow [kgmole/h] | 6.851 |
| Mass Flow [kg/h] | 123.4 |
| Std Ideal Liq Vol Flow [m3/h] | 0.1237 |
| Molar Enthalpy [kJ/kgmole] | -2.393e+005 |
| Molar Entropy [kJ/kgmole-C] | 181.2 |
| Heat Flow [kW] | -455.4 |

| Stream Name | Vapour 1 |
|---|---|
| Vapour / Phase Fraction | 1.0000 |
| Temperature [C] | 101.2 |
| Pressure [bar] | 1.013 |
| Molar Flow [kgmole/h] | 7.507 |
| Mass Flow [kg/h] | 135.2 |
| Std Ideal Liq Vol Flow [m3/h] | 0.1355 |
| Molar Enthalpy [kJ/kgmole] | -2.393e+005 |
| Molar Entropy [kJ/kgmole-C] | 181.3 |
| Heat Flow [kW] | -499.0 |
| Liq Vol Flow @Std Cond [m3/h] | 0.1333 |
| Fluid Package | *Basis-1* |
| Utility Type | |

### Demand Satisfaction

$$123.4+135.2=258.6\ kg/h$$

$$Water\ Density \cong 1000\ \frac{kg}{m^3}$$

$$1\ m^3 = 1000\ L$$

$$1\ L = 1\ kg$$

$$58.6 \frac{L}{h} \times 24 = 6206.4 \frac{L}{day}$$

### Energy Consumption

$$78.66\ kW \times 24 = 1887.84 \frac{kWh}{Day}$$

System Capacity: 487.6 kWdc (3251 m2)


Area Needed For The System

## Conclusion

- Simulation output and calculations prove that the system have met target specifications for demand satisfaction and energy consumption.
- PVWatts® Calculator shows the area that the system needs, which is less than 3500 $m^2$.
- Arduino microcontroller with sensors and pumps were used to read and adjust TDS and pH level.

## Acknowledgements

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